EVALUATING THE NEED FOR ENVIRONMENTAL MONITORING TO PREDICT TIMBER HARVESTING IMPACTS

ED&T 2611

Instrumentation to Monitor the Effects of Timber Harvesting

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ABSTRACT

Interviews with National Forest System (NFS) and Research Experiment Station personnel revealed a critical need for quantitative environmental data and a need for environmental modeling to predict the effects of timber harvesting. This need was based on a concern by NFS to find solutions for management problems, such as regeneration, productivity, and erosion, and for minimizing deleterious environmental impacts. Six primary environmental factors--heat, moisture, nutrients, gases, light, kinetic energy--were identified for which quantitative data are needed for modeling and predicting environmental impacts. Quantitative data gathered by monitoring not only would be useful to managers, but would also provide baseline data for developing prediction models.

A number of problems needing research are identified. Data provided by research in these areas would add to the value of environmental monitoring as a management tool. It is recommended that the Equipment Development Center at Missoula (MEDC) develop an environmental monitoring system for Service-wide use. Parameters to be monitored, sampling frequency, monitoring frequency, and accuracy needed are recommended here. Several equipment specifications expressed by NFS people are listed and recommended for consideration. It is further recommended that NFS and Research cooperate in developing environmental monitoring programs to derive maximum benefit from the data to solve forest management problems. Cooperation is also needed to compile information in existing literature into a form usable by managers.

CONTENTS

TABLES

GLOSSARY

APPLY RESEARCH RESULTS--Managers who felt that guides need to be developed from existing research information, as this information was often scattered or inaccessible to them. Guides need to be specific--generalized guides are often useless.

BASELINE DATA--Quantitative data that would identify natural conditions.

BETTER PLANNING--Those offices who needed better long-term planning to coordinate harvesting with other forest uses.

DATA INTERPRETATION PROBLEMS--Problems associated with interpreting data already collected.

DATA PROCESSING PROBLEMS--Problems with either equipment or personnel in getting data processed.

MONITORING ADEQUATE NOW--Those people who felt that they had enough quantitative data now.

MORE DATA REQUIRED--Quantitative data that would aid managers in selecting harvesting alternatives, provide information for Environmental Analyses Reports and Environmental Impact Statements, detect and quantify determinal impacts, complying with Federal/State/local laws.

NEED ENVIRONMENTAL MODELS--Models (or guidelines) based on field data that would provide managers quantified alternatives or predict harvesting impacts quantitatively.

RESEARCH NEED--Research required by managers to solve or provide information on a wide variety of harvesting problems.

REGENERATION--The establishment of primary species following logging, fires, etc., by natural or artificial methods.

SITE CLASSIFICATION--The classification of a site in terms of the major ecological factors acting there.

SITE PRODUCTIVITY--The plant biomass producing capability of a site, especially as affected by primary ecological factors.

SUCCESSIONAL DEVELOPMENT--The sequence of important plant species following disturbance, especially those of value to wildlife.

INTRODUCTION

Timber harvesting practices and associated activities have direct and far reaching effects on the forest environment and on management options following harvesting.

Almost any harvesting treatment changes the landscape. In addition, unseen changes such as loss of water quality often occur. Minimizing detrimental impacts should be the management goal. Criteria established in the National Environmental Policy Act (NEPA) directs management to prevent or eliminate environmental degradation. Man's lack of foresight has contributed to ecological problems we must now solve and avoid in the future.

Public concern over environmental degradation is responsible for this new focus on the environment. Many objections to harvesting impacts are being voiced; the Bitterroot controversy and the Monongahela court decision are two good examples. The result is that land management agencies now must prepare impact statements evaluating the consequences of activities such as timber harvesting.

Another result of environmental concern has been the establishment of environmental standards. Some of these standards have become laws at the Federal, State, or local level, and many more are likely to become laws. This creates problems for land managers, who do not have the quantitative data to determine if they have complied with these standards. A major criticism of environmental impact statements is directed at this lack of data. The accusation is that impact statements abound in qualitative terms that are not supported by quantitative data.

There are many reasons why more quantitative data have not been collected. Probably the major one is that conventional hand sampling techniques are prohibitive in terms of manpower and cost; and once collected it is difficult to handle the volumes of data.

In recent years, new concepts relating physical laws and principles to biological systems have been set forth. As a result, new techniques and methods for evaluating forest microenvironments are available to land managers.

The state of the art in instrumentation, too, has now reached the point where automation of field measurements is a reality, and handling large volumes of data also is no longer insurmountable. This means that environmental factors can be more easily quantified, which opens the door to a better understanding of the interactions between organisms and their environment.

This increased concern with environmental impacts and new opportunities for quantifying the environment most directly affects the land managers responsible for making decisions. It is important to understand the manager's problems and needs for quantitative data before attempting to provide methods and equipment for him to use. Consequently, managers in the National Forest System (NFS) were interviewed in 1975 to evaluate

their needs for environmental monitoring and determine the parameters they consider important for predicting timber harvesting impacts. Forest Service Research was also contacted and a limited literature search was conducted to evaluate available information and techniques. This report discusses the results of this survey and provides specific information that can be used for development of specifications for monitoring equipment. Specific recommendations are made based on results of the survey.

This evaluation is a cooperative effort between the Equipment Development Center and the Forest Residues Utilization R&D Program of the Intermountain Forest and Range Experiment Station. Both are Forest Service units based at Missoula, Montana.

METHODS

To determine NFS monitoring needs, the Intermountain Forest and Range Experiment Station (IF&RES) contacted eight Regions, 23 National Forests, and 19 Ranger Districts during the last 3 months of 1975. The distribution of the offices contacted in each Region is listed in table 1. Because of their relative close proximity, personnel in the Northern (1), Rocky Mountain (2), Intermountain (4), and Pacific Northwest (6) Regions were contacted by telephone. Timber Management personnel as well as other forest specialists (hydrologist, soil scientist, etc.) responded. A list of the specialists interviewed at Regional Offices and Supervisors' Offices is given in table 2. Interviews at the District level were limited to the Rangers or timber administration personnel. The response from all offices was good, and IF&RES felt the sample base was adequate.

Table 1.--Number of Forest Service units surveyed

Type of unit	Region									Totals
	1	2	3	4	5	6	8	9	10	
Ranger District	2	2	2	3	2	3	2	2	1	19
Supervisor's Office	3	3	4	3	4	3	2	2	0	24
Regional Office	1	1	1	1	1	1	0	1	1	8

Table 2.--Personnel interviewed at Regional and Supervisors' Offices

Type of unit	Region									Totals
	1	2	3	4	5	6	8	9	10	
Hydrologists	4	4	2	6	4	2	1	1	1	25
Soil scientists	3	4	2	3	3	2	1	2	1	21
Timber staff	3	4	5	6	4	2	2	3		30
Biologists	1	1	2	1	3	0	1	2	1	12
Landscape architects	0	1	0	2	0	0	0	0	1	4
Planners					1	3				4
Engineers		1		1		1			1	4
Geologists						1				1
Computer specialists									1	1

In order not to limit the responses of the forest managers, an essay questionnaire format was chosen over an objective type form. (Appendix A contains a sample interview form.) In many instances, land managers indicated a management problem area (e.g., lack of regeneration) but did not specify causes (e.g., moisture, temperature). Therefore, parameters were uniformly assigned by us in these cases; they were based on information received from specialists or from literature reviews. Appendix B lists the parameters assigned to each management problem area.

Our questionnaire was divided into two sections. In the first section, the forest environment is broken down into its major components. The objective was to determine the specific parameters of importance volunteered by land managers in each category. The second section consisted of questions directed at identifying the more general management problems and monitoring needs related to timber harvesting practices.

To determine the current knowledge and techniques in environmental monitoring, we also contacted researchers at five Forest Service Experiment Stations. A literature review was made on the parameters deemed feasible to monitor. Researchers were questioned on sources of information for solutions to specific problems and on whether predictive models developed from field data existed. Essentially the same information was sought in the literature review, but the short time frame dictated a meager review due to the scattered nature of the literature.

Data were tabulated by offices for both management problems and measurable parameters. Each office was counted only once even though more than one manager was interviewed. The total number of offices citing a management problem or measurable parameter were tallied for each Region and percentages were calculated based on the total number of offices contacted.

RESULTS

Management Problem Areas

Biological and site-related.--Management concern was directed toward biomass productivity of a site as it relates to timber, wildlife, water quantity and quality, and esthetics. For this reason responses from all offices indicated that site-related problems such as water quality, regeneration, and water quantity are important management problems (table 3). Regeneration was cited by 76 percent of all responding offices. This indicates that managers do not know the cause of failures nor how to predict reestablishment following harvesting. Lack of regeneration was cited as an unacceptable (harvesting) impact. Site productivity and classification as a means of identifying problem areas were related as problem needs by 47 percent of the responding offices.

The most frequently cited harvesting problem relates to vegetation development and its influence on water. Water quality and quantity were cited 82 and 69 percent of the time. Water standards were a particular concern in Regions 1, 4, 5, and 6, with 22 percent of all offices expressing this.

Table 3.--Management problem statements

Problem	Region 1	2	3	4	5	6	8	9	10	Total No.	Percent
	--Number of times problem stated--										
Biological and Site Related											
Water quality	5	5	6	7	5	4	4	4	2	42	82
Regeneration	4	6	5	7	6	4	3	4	0	39	76
Water quantity	4	6	7	7	4	1	2	2	2	35	69
Terrestrial	2	6	3	5	4	1	3	4	1	29	57
Geological survey	2	3	4	3	5	2	2	2	1	25	49
Site productivity	3	5	0	4	6	1	2	2	2	24	47
Site classification	3	5	3	2	4	1	3	2	1	24	47
Aquatic	2	3	3	4	5	4	0	0	1	22	43
Soil survey	2	3	5	0	4	0	3	2	1	20	39
Insect	1	2	1	1	4	2	0	3	0	14	27
Succession develop.	0	4	1	2	3	0	1	0	0	11	22
Water standards	4	0	1	1	2	3	0	0	0	11	22
Habitat typing	0	3	2	5	0	0	0	1	0	11	22
Disease	1	2	0	3	4	0	0	1	0	11	22
Administrative/Technical											
More data needed	5	3	5	5	5	7	3	3	2	38	75
Need environmental models	4	6	5	5	5	2	4	3	1	35	69
Research needed	4	3	5	5	4	5	3	3	1	33	65
Baseline data needed	4	3	4	2	4	3	1	1	2	24	47
Budget constraints	3	3	2	2	2	3	3	3	0	21	41
Data processing problems	1	4	2	2	5	0	3	3	0	20	39
Better planning	2	4	2	3	1	1	0	4	0	17	33
Better sampling techniques	2	2	2	2	3	2	0	0	2	15	29
Data interp. problems	0	4	2	2	2	2	0	1	1	14	27
Lack of personnel	2	0	2	2	2	1	2	3	0	14	27
Apply research results	0	3	2	3	2	0	0	1	2	13	25
Improved equipment	2	2	1	2	1	3	0	0	2	13	25
Monitoring adequate	0	1	2	0	0	1	0	1	1	6	12

Comparing responses from District personnel with Supervisors' and Regional Offices (table 4) revealed no major differences. The largest difference concerned post-harvest successional development of vegetation. District personnel mention this 11 percent of the time and other offices 28 percent.

Most offices expressed concern over erosion and compaction problems resulting from harvesting. This was indicated by the number of managers wanting to measure both soil loss (78 percent) and compaction (47 percent) (table 5);

Table 4.--Problem statement--Ranger Districts vs. Regional and Supervisors' Offices

Problem	Districts		Regional and Supervisors' Offices	
	No.	Percent	No.	Percent
	--Number of times problem stated--			
Biological and Site Related				
Regeneration	15	79	24	75
Water quality	14	74	28	88
Water quantity	12	63	23	72
Site productivity	10	53	14	44
Site classification	9	47	15	47
Soil surveys	6	32	14	44
Geological surveys	4	21	21	66
Succession development	2	11	9	28
Water standards	2	11	9	28
Administrative/Technical				
More data needed	13	68	25	78
Research needed	10	53	23	72
Data processing problems	10	53	9	28
Baseline data needed	7	37	17	53
Need environmental models	7	37	28	88
Budget constraints	6	32	15	47
Better planning	5	26	12	38
Data interpret. problems	4	21	10	31
Improved equip. needed	3	16	10	31
Monitoring adequate now	3	16	3	9
Lack of personnel	3	16	11	34
Better sampling techniques	2	11	13	41

managers also wanted to know how much soil loss is acceptable. Mass failure, primarily due to road construction, was listed as a management problem by 53 percent of the offices. Most stated that they didn't know whether compaction was a problem; they hadn't measured it, but would like to. Their concern was to identify under what conditions compaction would occur. The importance of soil loss and compaction was expressed because of their influence on both regeneration survival and its productivity.

Other problems concerned gathering site information; geological surveys, soil surveys, and vegetation surveys were desired by 49, 39, and 22 percent, respectively (table 3). These surveys are, in some cases, in varying stages of completion. Where surveys were usable or completed, the problem was not tallied.

Although 22 percent seems low for habitat typing, other kinds of vegetation classifications are being used, and 49 percent said they needed site classification methods.

Table 3 lists the responses by Region for the problem concerns. Ranger Districts indicated less of a need for geological surveys than Regional or Supervisors' Offices--21 and 66 percent. No apparent difference exists between Districts and other offices for habitat typing, site classification, or soil surveys. The parameters associated with surveys do not lend themselves to monitoring, but the data is needed for management decisions.

Other biological problems such as aquatic habitat, terrestrial wildlife, insect, and disease damage were expressed (table 3). Terrestrial wildlife (57 percent) and aquatic habitat (43 percent) were of most concern. Insects and disease problems were mentioned 27 and 22 percent of the time. A major wildlife concern was the effect of harvesting on wildlife populations and how migration patterns and calving areas might be affected. Each of the problems encompass many specific aspects, most of which do not lend themselves to monitoring.

Administrative and technical.--These considerations reflected overall information needs, the desire for quantitative data, and concerns about implementing monitoring programs. Results are listed in table 3. Seventy-five percent of all offices contacted said that more quantitative data is required to do an adequate job of timber harvesting, particularly with regard to predicting impacts. Here is a typical statement: "... the more data gathered the better, provided the data is usable for direct interpretation and not gathered for data gathering sake."

A major point expressed was that quantitative data would provide the facts we now lack to evaluate the extent of impacts that have taken place. Forty-seven percent of all offices expressed the need for baseline data that would aid in selecting harvesting alternatives. The need for environmental prediction models was expressed by 65 percent of all offices. This indicates their desire to understand environmental consequences of alternative harvesting methods and to predict these consequences before harvesting.

Ranger Districts, when compared with the Supervisors' staff and the Regional Offices, expressed slightly less concern for more baseline data. Districts did not state a need for environmental models as often (37 percent) as the R.O. and S.O. (88 percent). Districts also were less concerned with improving equipment, improving sampling techniques, and the need for more research. Data handling was more of a concern at the District level than at other offices (53 percent vs. 28 percent). Other factors that have a decided influence on environmental monitoring are cost and personnel; cost was noted by 41 percent of the offices, personnel by 27 percent. Districts were less concerned with budget constraints than were S.O.'s and R.O.'s: 32 percent vs. 47 percent. The same was true for personnel required for monitoring, 16 percent vs. 34 percent. It is important to note that no specific equipment costs and manpower requirements were discussed.

Measurable Parameters Identified by Managers

The measurable parameters NFS managers need to evaluate impacts and make management decisions are listed in table 5. Precipitation, soil nutrients, and soil moisture were the most commonly monitored at 92 percent. Monitoring air temperature, radiation, and soil temperature were mentioned by 90 percent. Water quality parameters such as suspended sediment, water temperature, and turbidity were next on the list at 88, 82, and 80 percent. Many other parameters are important also (tables 5 and 6) for evaluating timber harvesting. The 20 parameters mentioned most often are ranked in table 6. This provides some basis for making decisions on equipment development priorities. Comparing Districts and other offices (table 7) revealed little difference in parameters needing monitoring.

Table 5.--Parameters needing quantification

Parameter	Region									Total	
	1	2	3	4	5	6	8	9	10	No.	Percent
	--Number of times parameter stated--										
Atmospheric											
Precipitation	5	6	6	7	7	6	4	3	2	47	92
Air temperature	6	6	5	7	7	6	3	4	2	46	90
Radiation	6	6	5	7	7	6	3	4	2	46	90
Evapo-transpiration	5	6	5	7	7	6	3	3	2	45	88
Wind	5	6	5	7	6	6	3	4	2	44	86
Snow accumulation	5	6	5	7	5	5	0	3	2	39	76
Snow melt rate	1	0	2	4	2	0	0	0	1	10	20
Light quality	0	0	0	1	1	0	1	1	0	4	8
Soils											
Nutrients	5	6	6	6	7	6	4	5	2	47	92
Moisture	5	6	6	7	7	7	4	3	2	47	92
Temperature	6	5	6	7	7	6	3	4	2	46	90
Soil loss	3	5	6	7	7	2	4	4	2	40	78
pH	4	6	6	6	5	6	3	1	2	39	76
Compaction	3	2	5	3	4	3	2	2	0	24	47
Infiltration	1	1	2	3	3	0	1	1	0	12	24
Soil depth	1	0	0	0	4	0	0	1	1	7	14
Organic matter	0	1	1	0	0	1	1	0	1	5	10
Depth of bedrock	0	0	0	1	0	1	0	1	0	3	6
Soil water potential	1	1			1					3	6
Microbiology	0	1	0	0	0	0	1	0	0	2	4
Texture	1	0	0	0	0	1	0	0	0	2	4
Porosity						2				2	4
Plasticity					1	1				2	4
Cohesion		1				1				2	4
Bulk density						1				1	2
In place density						1				1	2
Water Quality											
Suspended sediment	6	6	6	7	5	4	4	5	2	45	88
Water temperature	5	6	6	7	4	4	4	4	2	42	82
Turbidity	5	6	6	7	4	4	4	4	2	41	80
Dissolved Oxygen	4	5	6	7	4	4	4	4	2	40	78
Water pH	4	5	6	7	4	4	4	4	2	40	78
Specific conductance	5	4	6	7	4	4	4	4	2	40	78
Water yield	5	6	6	7	7	1	3	2	2	39	76
Runoff timing	4	6	6	7	7	1	3	2	2	38	75
Coliform	4	4	6	7	4	4	2	3	2	38	75
Nitrogen	3	2	2	2	2	1	2	2	1	17	33
Phosphorus	3	1	2	2	2	1	2	2	1	16	31
Potassium	2	1	0	1	1	1	2	1	0	9	18
Subsurface flow	1	0	0	2	2	1	0	0	0	6	12
Water table					3	1		2		6	12
Pesticides	0	1		1	1				1	4	8
Oils	1			1						2	4
Salinity				1					1	2	4

Nearly all managers wanted information about the role these parameters play to help in selecting management alternatives and evaluating impacts. The general feeling was to monitor sites before, during, and after harvesting.

Table 6.--Overall ranking of parameters

Rank	Parameter	Percent
1	Soil moisture	92
2	Soil nutrients	92
3	Precipitation	92
4	Soil temperature	90
5	Radiation	90
6	Air temperature	90
7	Suspended sediment	88
8	Evapo-transpiration	88
9	Wind	86
10	Water temperature	82
11	Turbidity	80
12	Dissolved oxygen	78
13	Water pH	78
14	Specific conductance	78
15	Soil loss	78
16	Water yield	76
17	Snow accumulation	76
18	Soil pH	76
19	Timing of runoff	75
20	Coliform	75

1. What kinds of physical or biological site information is required or would be helpful in making decisions about proposed timber harvesting operations? Consider the following broad categories of environmental concern:

Geology -

Landform -

Soils -

Physical

Chemical

Water -

Quality

Quantity

Climate -

Macroclimate

Microclimate

Flora -

Trees

Shrubs

Herbaceous

Diseases

Residues -

Fauna -

Aquatic

Livestock

Terrestrial

Insect

For example, a manager planning a timber harvest needs to predict the effects on stream water quality to evaluate the impact on the fisheries and to ensure compliance of National and/or State standards. He feels that measuring water temperature, turbidity and pH two years before road construction will enable him to choose a harvesting alternative that will meet his objectives. In addition, he plans to continue the monitoring for two years after the harvest has been completed to reinforce his predictions and to gather data for future sales. Either the category of water-quality or fauna-aquatic could be used to list the parameters of temperature, turbidity, and pH.

Since interactions between the various environmental factors may be of greater importance than any single factor, feel free to address this as you see it.

2. What different or additional kinds of information should be obtained during and following harvesting operations, to measure actual environmental impacts and provide added basis for prediction?

3. What additional biological information, not included in discussions of (1) and (2) above, do you need to support management decisions, or to develop environmental analysis or impact statements?

4. What do you view as major weaknesses in managers' ability to adequately predict environmental impacts due to timber harvesting, associated road construction, and other on-site activities?

5. What unacceptable impacts have you observed as a result of timber harvesting activities?

6. What are your pre- and post-harvest environmental monitoring needs that are not currently being satisfied?

7. What general types of monitoring equipment are you now using and in what form is the data output?

8. What are your data handling capabilities in relation to:

A. Personnel training and expertise;

B. Availability of data processing equipment and computer facilities.

APPENDIX B

PARAMETERS ASSIGNED TO PROBLEMS

PROBLEM	PARAMETERS ASSIGNED
Regeneration	Wind
Productivity	Precipitation
Successional Development	Soil moisture
	Soil nutrients
	Radiation
	Soil temperature
	Air temperature
	Soil pH
	*Snow accumulation
	*Snowmelt rate

* Snow accumulation and melt rates were assigned only in conjunction with regeneration problems and to those offices whose areas have significant snowfall.

Water Quality	Suspended sediment
	Turbidity
	Water temperature
	Dissolved oxygen
	Specific conductance
	Coliform
	Water pH

Assigning parameters to problems was necessary as the land manager would often indicate a problem existed but did not offer specific parameters requiring measurement even though the person felt monitoring was a feasible alternative to solve the problem.

APPENDIX C

LIST OF IMPORTANT PARAMETERS REQUIRED TO DEVELOP MODELS

I. SIX PRIMARY FACTORS

A. HEAT

TEMPERATURE - Soil - Soil surface temperatures and possibly temperatures at several depths--many transducers available.

Air - Several samples may be needed to determine heat flow--many transducers available.

Organism - Plant (and residue) temperatures in combination with above needed to determine heat exchanges--some transducer development may be required.

RADIATION - Solar - Several samples may be needed depending upon canopy conditions--some transducers available but refinement may be required.

Net - Measurement of all wavelengths needed to describe fluxes between surface and atmosphere--sampling dependent on canopy conditions--some transducers available but refinement may be required.

B. MOISTURE

SOIL MOISTURE -

Water Potential - Measurement at several depths at several locations needed--transducers (soil physchrometers) available but some refinement may be required.

Percent moisture - May be required for compaction models--samples should be taken at several locations--some transducers available.

PLANT MOISTURE

Water potential - Is required to help determine water stress of plants in relation to soil water potential--transducer development required.

RESIDUE MOISTURE

Percent moisture	- Is needed to aid in determining decay rates and to provide data for fire (controlled and uncontrolled) analysis--several transducers available.

ATMOSPHERIC

Relative humidity	- Needed to determine moisture stress--also possibility of monitoring SPECIFIC HUMIDITY in addition to or in place of relative humidity--several samples may be required depending on canopy conditions--transducers available but may require some development.
Evapo-transpiration	- Potential evapo-transpiration can be calculated using several of the above parameters. Techniques may be needed for measuring actual fluxes.

PRECIPITATION

All forms	- Several sample points desirable--some methods available but additional development may be needed.

SNOW

Accumulation and melt rate	- Both depth and water content needed--transducers available for depth but development may be required for moisture content.

C. LIGHT

QUALITY

420-480 millimicrons 620-700 millimicrons	- Are important wavelengths affecting photosynthetic rates--several samples may be required depending upon canopy conditions--transducer status unknown, possible use of photocells.

INTENSITY

All wavelengths	- Sample frequency dependent on canopy conditions--transducer status unknown, possible use of photocells.

D. GASES

SOIL -	Oxygen	- Sampling at several depths may be required--sensor status unknown.
	Carbon dioxide	- Samples must be located in close proximity to O_2 samples--sensor status unknown.

E. KINETIC ENERGY

WIND -		
	Speed and azimuth	- Sample frequency dependent on canopy conditions--transducers available but may require modification.

F. NUTRIENTS

MACRO -	Nitrates	- Sample locations should be in close proximity to O_2 samples--transducers are available but some development is required.
	Remaining macronutrients	- The remaining macronutrient data can be obtained from soil survey.
MICRO -	All	- Obtained from soil survey data.
MODIFIERS -	pH	- Although not a nutrient, it may be desirable to monitor soil pH--transducers are available.

II. WATER QUALITY-QUANTITY

SEDIMENT -	Turbidity	- Measured in Jackson Turbidity or Candle Units (JTU or JCU)--many states have specific quantitative standards pertaining to turbidity--transducers available.
	Suspended sediment	- Measurement of the amount of clay, loam, sand, etc.--transducer status unknown.
	Bedload sediment	- Not a base requirement by either Region 6 or Region 1, yet many hydrologists felt bedload was an important parameter to monitor--monitoring is difficult.
TEMPERATURE		- Many states have quantitative standards--several transducers available.

GASES - CO_2	- Required by Region 1 hydrologists--transducer status unknown.
Dissolved O_2	- Should be monitored in close proximity to temperature sensors if there is a possibility of varying water temperatures--transducer status unknown.
CHEMICAL	
Specific conductance	- Related to the total concentration of ionized substance--transducers are available.
Nitrogen	- Measurement of TOTAL NITROGEN is proposed by Region 1 hydrologists--methods for monitoring need to be developed--other hydrologists have suggested monitoring NITRATE--transducers are available.
PO_4	- Region 1 requires PO_4 measurement, especially if burning is involved--transducer status unknown.
Other chemical	- In some states other chemical analysis is required--specific ion probes, etc., may need development or modification.
pH	- Monitoring required by Region 1--transducers available.
BIOLOGICAL	
Symbionts	- Techniques not presently available.
Coliform	- Both TOTAL and FECAL COLIFORM measuring required by R-6--monitoring important if water is used for culinary purposes--transducer status unknown but monitoring is probably not feasible.
QUANTITY - Discharge	- Measurement of water flow is required by R-1 and R-6--accurate monitoring may be difficult.

ADDITIONAL SUPPORTIVE INFORMATION

Soil survey	- Physical and chemical properties of soils.
Geological survey	- Landform analysis and site characteristics such as percent slope, aspect, etc.

Vegetative analysis	- Habitat typing or other comparable form of vegetative analysis.
Wildlife survey	- Terrestrial species present, populations, migrations, etc.
Insect and disease survey	- Species of organisms as to potentials for damage and spread.

APPENDIX D

LISTING OF RESEARCH NEEDS PROVIDED BY NFS AND RESEARCH

1. Identification of physiological requirements of organisms.

2. Identification of environmental variability within habitat type mapping units.

3. Development of methods to extrapolate results between sites.

4. Identification of effects of alternative harvesting methods on water quality.

5. Identification by site of specific microclimatic effects on regeneration.

6. Methods of predicting soil loss resulting from harvesting operations.

7. Identification of site productivity in terms of biomass potentials.

8. Identification of environmental factors as they influence insect populations.

9. Identification of habitat requirements for wildlife species.

10. Methods for evaluating compaction hazard for various soils as related to logging equipment.

11. Identification of rooting depths of various plant species.

12. Methods to identify marginal sites for regeneration (where do potential problems exist?).

13. Identify what levels of removal of residue (slash) are detrimental to the site.

14. Identify the effects of harvesting on population levels of wildlife species.

15. Develop guidelines that indicate the effectiveness of uncut buffer strip in reducing erosion and enhancing water quality.

16. Identification of natural variability in water quality parameters of various streams.

17. Identify environmental-disease organism relationships and how they are influenced by harvesting.

18. Relate habitat type classification to soil types.

19. Need to identify seed production potentials by habitat type.

20. Standards are needed to relate water quality parameters to aquatic populations.

21. Relate soil characters to soil quality and productive capacity, including physical, chemical, and biological characteristics.

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